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Synthesis of Research and Education, Industry and Academia - A Case Study of 2-D Heterogeneities of Poroperm, Ultrasonic and Resistivity on Sub-meter

M.C. Poppelreiter* (Shell International E&P BV) & J. Hornung (Technische Universität Darmstadt)

SUMMARY

Spatial relationships of rock and petrophysical properties on a grid block scale (decimeter) are poorly known. These however are input to effective property models and near well-bore heterogeneities in geocellular models. To investigate and visualize such relationships slabs of typical clastic and carbonate reservoir rocks were analyzed. To this end rock properties such as grain size, sorting, pore types as well as petrophysical properties like porosity, permeability, ultrasonic speed and resistivity were systematically described. Results are displayed as property maps.

Investigations will be used for training young petroleum engineers to link geology to petrophysical properties. Relationships are input to geological decisions such as geostatistics or geologically meaningful upscaling strategies.

Introduction

A joint research project was set up between Shell International E&P (Netherlands) and Technical University of Darmstadt (Germany). Project objective is to investigate the 2D distribution of petrophysical properties and its relationships to geological characteristics.

To this end 7 rock slabs were selected in quarries. Research results will be used for geological training in reservoir characterisation and modelling both at the University and at Shell. The results are integrated in Shell “Digital Geology” Project, hosted at Shells Technology Centre in the Netherlands.

Work flow

Seven slabs of typical clastic and carbonate reservoir rock were selected. Three slabs are of a fluvial sandstone. Each has dimensions of 50cm to 50cm. Another four slabs are of ramp limestone and dolomite. These have a size of 100cm height to 30cm width each. All slabs have a thickness of 6cm. This is to obtain plug samples. Plugs have a diameter of 25mm and a length of 30 to 38mm. Core plugs are required especially for porosity measurements. These are carried out using a relationship between raw density and bulk density. Subsequently other measurements such as permeability, ultrasonic speed, and resistivity are carried out these plugs. The rock slabs are oriented geologically with bedding planes parallel to ground. Therefore drilling following bedding planes, similar to side wall cores in a well. Additionally smaller scale plugs (10mm) were drilled to investigate scaling effects (up- and down) of petrophysical properties. Thus approximately 1000 data points were derived in total.

Geological characterisation is based on facies types classification and detailed geological characterisation. Representative thin sections are produced from each slab. These are investigated using normal, polarized, and UV-light, cathodoluminescence and pore space imaging techniques (SEM, micro-CT).

Concept

Rock slabs superimposed maps of petrophysical measurements are used for learning and development in the Shell technology centre. Most significant is to display geological control on petrophysics. Additionally the combination of geology and petrophysics should aid petroleum engineers to make meaningful decisions, particularly on geocellular model construction.

The sandstone slabs are chosen from various portion of a channel that reflect decrease in stream power, i.e., channel base with erosional surfaces, channel centre with bar forms and channel margin with high proportion of fines.

Bunter sandstone

Figure 1 All of the investigated sandstone slabs to fluvial deposits:

1) channel base, 2) channel centre, 3) channel margin.

The set of carbonate slabs represents a transition from landward lagoonal through shoal ramp to the open marine foreshoal environment. These show different pore types and pore type architecture.

Distinct features of these rocks are: strongly diagenetically overprinted dolomite, a wacke to packstone, showing herringbone stratification and mud drapes, it is classified as a tidalite, an oolitic grainstone with crinoid fragments and peloids, and a grainstone to rudstone consisting mainly of shell debris, representing the high energy shoal environment.

Muschelkalk

Figure 2 The carbonate slabs are from a carbonate shoal: 4) strongly diagenetically overprinted dolomite (mudstone), 5) tidalite (wacke- to packstone), 6) oolitic shoal (packstone), 7) bioclast dominated by bivalve debris foreshoal (grainstone/rudstone).

Summary

The project reveals new insights in effects of one- and two-dimensional patterns of heterogeneities typical for different environments. It gives insights into the 2D architecture of geology and petrophysics. Applied issues such as upscaling, permeability distribution, effective property modelling and its relationships to the environmental specific geological architecture.

The project facilitates the early focus of university students to industry relevant applications. Industry in turn has access to well trained graduates and latest research results.

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